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Original Research

Investigating Beliefs Toward Physical Activity in Pregnancy Among Women With and Without Gestational Diabetes Mellitus

Sophie Pellerin BSc[a]; Stéphanie Girard PhD[b]; Pier-Olivier Caron PhD[c]; Jean Lemoyne PhD[b]; Laurence Simard MSc[b]; Véronique Babineau MD[d]; Jean-Patrice Baillargeon MD[e,f]; S. John Weisnagel MD[g,h]; Evelyne Rey MD[i,j]; Stephanie-May Ruchat PhD[b,*]

[a] Faculty of Medicine, University of Montréal campus Mauricie, Trois-Rivières, Québec, Canada
[b] Department of Human Kinetics, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada
[c] Department of Human Sciences, Letters and Communication, Université TÉLUQ, Montréal, Québec, Canada
[d] Department of Obstetrics and Gynecology of CIUSSS de la Mauricie et du Centre-du-Québec, affiliated with the University of Montréal, Trois-Rivières, Canada
[e] Department of Medicine, Université de Sherbrooke, Sherbrooke, Canada
[f] Research Centre of the CHU de Sherbrooke, Sherbrooke, Canada
[g] Department of Medicine, Faculty of Medicine, Université Laval, Québec, Canada
[h] Research Centre of the CHU de Québec, Endocrinology and Nephrology Axis, Québec, Canada
[i] Department of Medicine, University of Montréal, Montréal, Canada
[j] Department of Obstetrics and Gynecology, CHU Sainte-Justine, Montréal, Québec, Canada

Key Messages

- Prenatal physical activity benefits maternal and offspring health, including reduced gestational diabetes (GDM) risk.
- Despite guidelines, most pregnant women, including those with GDM, remain insufficiently active.
- Intention and perceived control are key drivers of physical activity during pregnancy.
- GDM-specific beliefs were identified, such as pregnancy-related discomfort, and provider approval, shaping physical activity intention.
- Supports tailoring interventions to belief profiles will be key to improve prenatal physical activity engagement.

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ABSTRACT

Objectives: Physical activity (PA) is beneficial for pregnant women, including those who develop gestational diabetes mellitus (GDM). However, only a few are sufficiently active to reap health benefits. In this prospective cohort study we aimed to: 1) validate the Theory of Planned Behaviour (TPB) model for predicting moderate-to-vigorous PA (MVPA) among pregnant women; 2) examine whether the model varies by GDM status (with or without GDM); and 3) identify beliefs predicting intention toward MVPA and assess whether these beliefs differ by GDM status.
Methods: Women with and without GDM completed 2 questionnaires: the first assessed TPB constructs; the second, completed 2 to 4 weeks later, assessed MVPA behaviour. Structural equation modelling and multigroup analyses were conducted.
Results: The sample included 191 women without and 149 with GDM. The main results show that perceived behavioural control (PBC) was a significant moderator of the relationship between intention toward MVPA and the behaviour, the relationship being stronger when PBC was moderate to high. Some beliefs that indirectly predicted the intention toward MVPA varied between women with and without GDM. For example, in women with GDM, higher intention was found in those believing that MVPA would unlikely cause discomfort or pain related to pregnancy (β=0.289, $p<0.001$), that their health

* Address for correspondence: Stephanie-May Ruchat PhD, Department of Human Kinetics, Université du Québec à Trois-Rivières, 3351 Boulevard des Forges, Trois-Rivières G9A 5H7, Canada.
Email address: Stephanie-May.Ruchat@uqtr.ca

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professionals would approve MVPA practice (β=0.149, p=0.023), and that even if they lack time (β=0.282, p<0.001) or are tired (β=0.185, p=0.008), they would practice MVPA.
Conclusions: Our results highlight the importance of pregnant women's confidence in their ability to be active and of targeting specific beliefs when designing interventions promoting prenatal PA.
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Mots-clés:
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théorie du comportement planifié

RÉSUMÉ

Contexte : L'activité physique (AP) est bénéfique pour les femmes enceintes, y compris celles qui développent un diabète gestationnel (DG). Cependant, seules quelques-unes d'entre elles sont suffisamment actives pour en retirer des bénéfices pour la santé. Cette étude de cohorte prospective visait à 1) valider le modèle de la théorie du comportement planifié (TCP) pour prédire l'activité physique modérée à vigoureuse (APMV) chez les femmes enceintes, 2) examiner si ce modèle variait en fonction du statut du DG (avec ou sans DG), 3) identifier les croyances prédisant l'intention de pratiquer une APMV et évaluer si ces croyances différaient selon le statut du DG.
Méthodologie : Des femmes atteintes ou non de DG ont répondu à deux questionnaires : le premier évaluait les construits de la TCP ; le second, complété deux à quatre semaines plus tard, évaluait le comportement en matière d'APMV. Une modélisation par équations structurelles et des analyses multigroupes ont été réalisées.
Résultats : L'échantillon comprenait 191 femmes sans DG et 149 femmes avec DG. Les principaux résultats ont montré que le contrôle comportemental perçu (CCP) constituait un modérateur significatif de la relation entre l'intention de pratiquer une APMV et le comportement, cette relation étant plus forte lorsque le CCP était modéré à élevé. Certaines croyances prédisant indirectement l'intention de pratiquer une APMV variaient entre les femmes avec et sans DG. Par exemple, chez les femmes atteintes de DG, une intention plus élevée a été observée chez celles qui pensaient que l'APMV était peu susceptible de causer une gêne ou une douleur liée à la grossesse ($\beta = 0{,}289$, $p < 0{,}001$), que leurs professionnels de santé approuveraient la pratique d'une APMV ($\beta = 0{,}149$, $p = 0{,}023$) et que même si elles manquaient de temps ($\beta = 0{,}282$, $p < 0{,}001$) ou étaient fatiguées ($\beta = 0{,}185$, $p = 0{,}008$), elles pratiqueraient une APMV.
Conclusion : Nos résultats soulignent l'importance de la confiance des femmes enceintes en leur capacité à être actives et de cibler certaines croyances spécifiques lors de la conception d'interventions visant à promouvoir l'activité physique prénatale.
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Introduction

Background

Strong evidence shows that regular prenatal physical activity (PA) offers multiple short- and long-term benefits for the health of the mother and her offspring. Among the short-term maternal benefits highlighted in recent meta-analysis are reduced gestational weight gain [1–3], risks of excessive gestational weight gain [1,3], hypertensive disorders of pregnancy, gestational diabetes mellitus (GDM) [3,4], as well as prenatal depression [3,5]. Maternal prenatal PA has also been associated with a lower risk of preterm delivery [6]. These benefits are not only observed in women experiencing uncomplicated pregnancies but also among those with complications, such as GDM [7]. In women diagnosed with GDM, PA confers additional benefits by improving glycemic management and potentially reducing the need for pharmacologic treatment when insulin therapy is required [8]. Beyond these short-term effects, prenatal PA is increasingly recognized for its long-term protective role in maternal and offspring health, thereby contributing to the early-life prevention of chronic disease across the life course. Literature reviews [9,10] highlighted that regular PA during pregnancy is associated with reduced postpartum weight retention; lower risk of cardiometabolic diseases, including obesity and type 2 diabetes; and improved metabolic and neurodevelopmental outcomes in offspring. Reflecting this evidence, international [11] and Canadian guidelines recommend that all pregnant women without medical contraindications, including women with GDM, accumulate at least 150 minutes of moderate-intensity PA per week [7].

PA, along with dietary modification, is a central component of GDM management [12] that aims to optimize glycemic management, support appropriate fetal growth, and prevent maternal complications [13]. However, both dietary modifications and PA are frequently described as demanding. Dietary management can generate considerable stress, social constraints, and feelings of restriction, and is often perceived as burdensome [14–16]. Similarly, PA may be experienced as challenging, particularly when added to the cumulative demands of GDM self-management, including dietary monitoring, glucose testing, medical appointments, fatigue, and competing responsibilities [17]. In this context, PA can represent an additional burden within an already intensive care regimen. Despite these well-established benefits and clear clinical guidelines, adherence to prenatal PA recommendations remains low. A recent Canadian observational study reported that 72.5% of pregnant women do not meet PA guidelines [18]. Comparable, or even poorer, levels of PA have been observed among women diagnosed with GDM in Asia and South America [19–21]. Collectively, these findings indicate that both pregnant women with and without GDM are insufficiently active to fully benefit from the protective effects of prenatal PA for maternal and offspring health.

Theoretical framework

To promote PA practice among pregnant women, it is essential to understand the determinants underlying persistently low participation levels. The Theory of Planned Behaviour (TPB) [22] provides a well-established framework for examining health-related behaviours [23], including PA during pregnancy [24]. Within this model, behaviour is primarily driven by intention (INT) and perceived behavioural control (PBC), with intention shaped by attitude (ATT) toward PA, perceived social norms (SN; e.g. expectations from health-care providers or family), and PBC. These constructs are underpinned by behavioural, normative, and control beliefs (BB, NB, and CB, respectively), which reflect pregnancy-specific perceptions, such as safety concerns, social support, and perceived physical or contextual barriers. Importantly, recent developments in TPB highlight PBC as a key moderator of the intention–behaviour relationship, such that strong intentions translate into PA engagement only when women perceive sufficient control over pregnancy-related constraints [25]. This moderating role of PBC was supported in a recent meta-analysis [26], underscoring its relevance as a central intervention target in the prenatal context.

Research applying the TPB to prenatal PA has predominantly focussed on women without GDM [26–32]. Taken together, these studies showed that prenatal PA is mainly driven by intention and PBC [26–28,31,32], with intention influenced by ATT, SN, and/or PBC [27–29,32,33], although the relative contribution of these determinants varies across pregnancy contexts. Emerging evidence also suggests that PBC may moderate the intention–behavior relationship, such that women are more likely to engage in PA when they perceived sufficient control over physical, social, and environmental constraints [30]. However, these findings are largely derived from studies conducted among women without GDM and may not be directly transferable to women with GDM, for whom PA is not only a health-promoting behaviour but also a cornerstone of glycemic management.

Studies have also examined TPB-related beliefs during pregnancy, identifying perceived benefits such as reduced fatigue, improved weight management, enhanced psychological well-being, and preparation for childbirth, alongside consistent barriers including physical discomfort, fatigue, time constraints, and lack of motivation [30,33–39]. Yet, in women with GDM, these beliefs are likely to be shaped by additional clinical factors, including concerns about glycemic management, fear of hypoglycemia, uncertainty regarding exercise safety, and the burden of intensified medical monitoring [17,40–42]. Failure to account for these condition-specific perceptions may partly explain the limited effectiveness of generic PA counselling in women with GDM.

Study aims and objectives

Despite the central role of PA in first-line GDM management, very few studies have applied the TPB framework to understand PA behaviour in women with GDM [35], and none have examined whether the predictive structure of the TPB or its underlying beliefs differ according to GDM status. Addressing this gap is clinically important, as identifying GDM-specific motivational and control-related determinants of PA can inform the development of tailored, clinically integrated interventions that better support glycemic management and potentially reduce the need for pharmacologic treatment. Guided by the TPB, our study therefore aimed to 1) validate the TPB model for predicting MVPA in pregnant women; 2) determine whether this model varies based on women's GDM status (with GDM or without GDM); 3) identify which beliefs predict the intention toward MVPA in pregnant women; and 4) understand whether beliefs differ according to women's GDM status.

Methods

In this study, the term "women" refers to individuals classified as female based on biological sex, as pregnancy and GDM are defined based on biological sex.

Study design

We used a prospective correlational design to explore beliefs associated with prenatal PA among women with and without a diagnosis of GDM. This study was reviewed and approved by the local research ethics committee. Written informed consent was obtained from all participating women.

Inclusion and exclusion criteria

Inclusion criteria were: being a woman $\geq$18 years of age; having access to the Internet; carrying a singleton pregnancy; being $\leq$34 weeks pregnant at the time of recruitment; being either diagnosed with GDM or having no diagnosis of GDM at the time of recruitment; and having no contraindications to PA or movement restrictions [7].

Recruitment of participants and procedure

Participants were recruited between February 2022 and May 2024 using multiple strategies, such as advertisement on a social media platform (Facebook) and placing recruitment posters in various locations frequented by pregnant women (perinatal clinics, obstetrics and gynecology clinics, community centres, etc). Recruitment material indicated that the study was about prenatal PA and its determinants but invited women with and without GDM, whatever their PA level, to participate. In partner institutions, medical staff or research assistants gave to pregnant women a leaflet presenting the project. Online publications, posters, and leaflets displayed a QR code and a link that led directly to the information letter and consent form, and then to the electronic questionnaire.

To calculate sample size, considering that we conducted path analyses, we considered the N:q ratio (participants relative to number of parameters). Sixty parameters were included in the final model. Knowing that the minimum acceptable ratio is 5:1 [43], a minimum sample size of 300 participants was requested. Considering a 20% loss to follow-up, we needed to recruit 360 participants.

Data collection

Data were collected through electronic questionnaires (hosted on the Qualtrics platform) at 2 time points: upon acceptance to participate in the study (baseline), and 2 (women with GDM) to 4 (women without GDM) weeks later (follow-up). The baseline questionnaire collected information to characterize the sample: personal and gestational characteristics (e.g. age, prepregnancy weight, height, education level, ethnicity, gestational age, and if diagnosed with GDM: gestational age at GDM diagnosis, first diagnosis), levels of PA over the past month. The TPB psychosocial constructs were also collected at baseline. The follow-up questionnaire collected information about PA levels to provide the data for analysis. Data authenticity verification was therefore limited to ensure timely completion of follow-up questionnaires. No additional response pattern or completion-time analyses were conducted.

Assessment of prenatal PA level

Participants' PA levels in both questionnaires were assessed using the French version of the International Physical Activity Questionnaire (IPAQ) [44], measuring low, moderate, and vigorous PA intensity over the past week. The IPAQ is a self-administered questionnaire frequently used to assess PA levels in populations of pregnant women [45]. It has been validated and shows good psychometric properties when used among pregnant women [45]. In the context of our study, the IPAQ was used to assess PA over the past 4 weeks (baseline) and over the past 2 to 4 weeks (follow-up) to obtain a more comprehensive and representative picture of actual PA habits, reducing the influence of one-off events that may be more frequent during pregnancy.

Assessment of psychosocial constructs

To study the TPB constructs, a precise definition was established, following Ajzen and Fishbein's [46] recommendation. The studied behaviour was engaging regularly (action) in PAs (target) in daily life (context) during pregnancy (time frame). To clarify what constitutes regular PA practice in the context of this study, the following definition was provided to participants: "Practicing physical activity regularly means accumulating at least 150 minutes (2.5 hours) of physical activity per week (e.g. 5 sessions of 30 minutes or 3 sessions of 50 minutes) at moderate or vigorous intensity" [7]. The baseline questionnaire required participants to assess the TPB constructs on a 7-point Likert-type scale; the variables were intention (3 items), ATT (6 items), SN (2 items), PBC (4 items), BB (8 items), NB (4 items), and CB (8 items). Two BB were recoded because their scales were reversed (e.g. "If I practiced regularly one or more physical activities in my free time over the next month [over the next 2 weeks for women with GDM], I would be more tired/have pregnancy-related discomforts and pains"; unlikely = 7, likely = 1). For these beliefs, following the approach of Gagné and Godin [47], only the expectancy components were retained, rather than combining expectancy and value. Psychosocial construct included in the baseline questionnaire are shown in Supplementary Table 1. The salient model beliefs used were identified through a prior elicitation study conducted by our team, following the methodology outlined by Ajzen and Fishbein [46]. See Simard et al for more information about the study [30].

Data analysis

Multivariate normality was tested using the Mardia coefficient [48,49], which revealed a violation of this assumption ($M>5$). Therefore, the maximum-likelihood modelling procedure with robust estimates was used to conduct structural equation modelling (SEM) [50] with the latent moderated structural equations (LMS) procedure to test the interaction model [51]. All analyses were conducted with Mplus software version 8. Internal consistency reliability was verified with the McDonald omega (ω) for the 4 latent variables. They were computed based on the Girard et al [52] procedure. Reliability diagnostics revealed high (>0.85) to very high (>0.90) internal consistency for each construct ($\omega_{attitude} = 0.904$, $\omega_{PBC} = 0.850$; $\omega_{norms} = 0.891$ for $\omega_{intentions} = 0.945$).

To validate the TPB model for predicting MVPA in pregnant woman (objective 1), we first tested the structural model (model 1; see Figure 1). Goodness of fit was determined using specific indices [53]: the comparative fit index (CFI) and the Tucker–Lewis index (TLI) should be >0.950; the root mean square error of approximation (RMSEA) and the standardized rooted mean square residual (SRMR) should be <0.08. Next, we tested the model with the interaction term (model 2; see Figure 2). Interpretation of the goodness of fit of the model with the interaction term was done with the log-likelihood ratio test because the fit indices are not provided when using LMS [54]. The significant interaction was then interpreted using the Johnson–Neyman graphical method [55], which provides zones of significance of the interaction [52].

Once the structural model was deemed appropriate (i.e. model 2, with the interaction term), we investigated a multigroup SEM analysis between the GDM and the non-GDM subjects [56] to determine whether the model varies based on women's GDM status (objective 2). Then, 3 submodels (1 for each set of beliefs: BB→ATT→INT; NB→SN→INT; and CB→PBC→INT) were analyzed using SEM and multigroup SEM to identify which beliefs predicted the intention toward MVPA in pregnant woman (objective 3), and to verify whether these beliefs differ according to women's GDM status (objective 4).

Ethics approval

This study was reviewed and approved by the local research ethics committee (Université du Québec à Trois-Rivières [CER-22-285-10.01] and Centre intégré universitaire de santé et de services sociaux de la Mauricie-et-du-Centre-du-Québec [MP-29-2022-264, 827]). Written informed consent was obtained from all participants.

Results

Participants

A total of 448 women were initially recruited and completed the first questionnaire. Of these, 192 had a diagnosis of GDM and 256 did not. Two to 4 weeks later, 361 women completed the follow-up questionnaire: 157 women with GDM (GDM retention rate 81.8%) and 204 women without GDM (non-GDM retention rate 79.7%). No women without GDM at recruitment were diagnosed with GDM between recruitment and follow-up. Women who were told by their health-care provider to stop exercising between the 2 assessments were excluded from the analyses (7 women with GDM and 4 women without GDM). Moreover, weekly MVPA values exceeding 450 minutes were considered extreme (as this corresponds to more than 3-fold the recommended 150 min/week of MVPA) and excluded to minimize the influence of implausibly high self-reported activity levels on model estimates (1 woman with GDM and 9 women without GDM). As a result, 149 women with GDM and 191 women without GDM were included in the analysis, for a total of 340 women. There were 11 missing data patterns, and any pair of variables was complete by at least 98.5%. The demographic characteristics of the women who completed the study were similar to those of the women lost to follow-up or excluded from the analysis. Figure 1 shows the number of participants at each stage of the study.

Descriptive statistics of participants

Table 1 presents the characteristics of the participants. Overall, women were in their 30s; nearly all were Caucasian, most (70%) held a university degree, and half were overweight or obese. The majority (57%) were primigravida and most (80%) were recruited in their second or third trimester of pregnancy. The majority (62%) did not meet the Canadian PA recommendations at baseline. Compared with women without GDM, those with GDM were more likely to be in a later stage of pregnancy, to be non-Caucasian, to have a lower education level, to present with obesity, and to be less active.

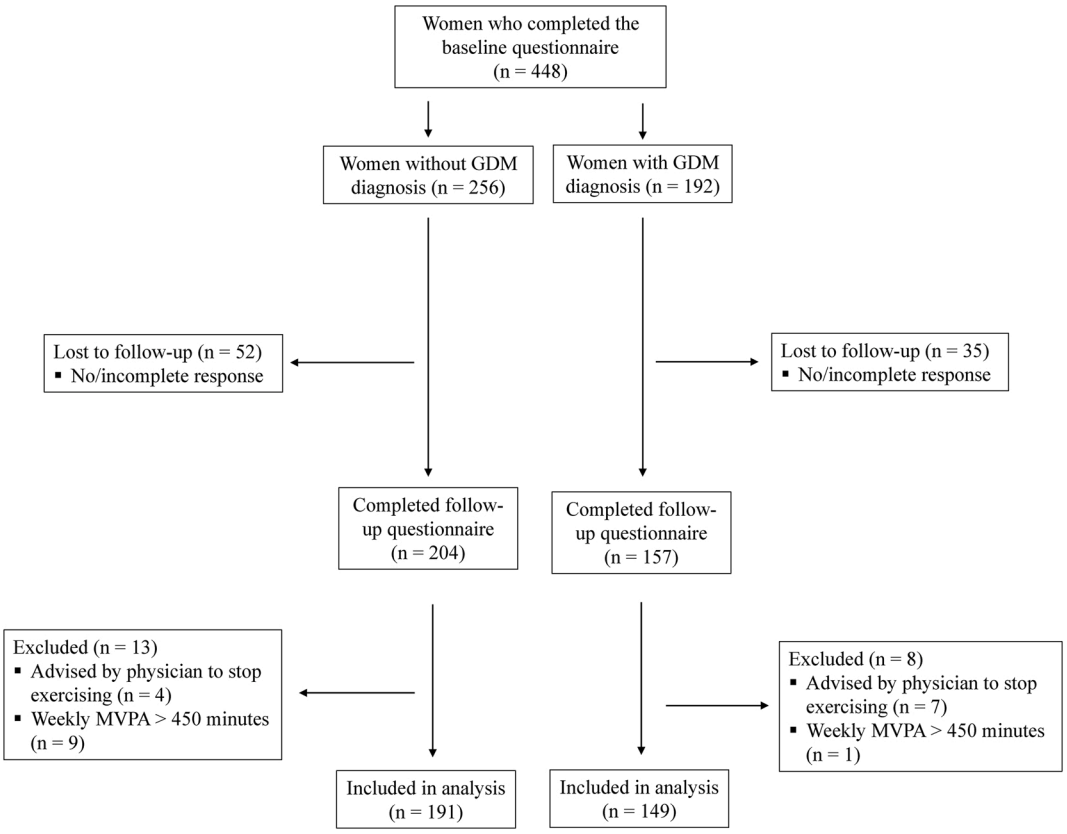


Figure 1. Flow diagram of participant recruitment and follow-up. *GDM*, gestational diabetes mellitus; *MVPA*, moderate-to-vigorous physical activity.

Validation of TPB model for predicting MVPA in pregnant woman (objective 1)

We first tested the structural model to verify its fit indices, which were close to good fits: $\chi^2_{(98)} = 672.543$, RMSEA = 0.131, CFI = 0.863, TLI = 0.832. To improve the model fit, we added disturbances based on modification indices, theoretical coherence, and parsimony. Four disturbances between items were added to reach acceptable fit indices: $\chi^2_{(94)} = 291.291$, RMSEA = 0.079, CFI = 0.953, TLI = 0.940. The final model is shown in Figure 2. All coefficients were significant ($p<0.001$).

Figure 3 shows the same model with the addition of PBC and the interaction term (PBC × intention) to predict MVPA. Results of the log-likelihood ratio test were significant, indicating that the model with the interaction had a better fit than the previous one: $D_{(2)} = -2[(-7{,}123.151) - (-7{,}137.559)] = 14.408$, $p<0.001$. The model shows a significant moderating effect of PBC on the relation between MVPA and intention ($\beta=0.19$, $p<0.001$).

Figure 4 shows the Johnson–Neyman plot. Considering that the interaction is significant when the blue lines do not include intention B=0, it reveals that the interaction occurs at moderate and high levels of PBC (when PBC is −0.60 SD and more).

Variation of TPB model based on women's GDM status (objective 2)

For the multigroup comparison, the unconstrained model was significantly different than the constrained model, $\chi^2_{(10)} = 45.973$, $p<0.001$, suggesting that there are some significant differences between women with and without GDM. Further inspection shows that there was a marginal statistical difference between the estimate of ATT on intention (d=0.296, p=0.06; see Figure 3). Specifically, the relation between intention and ATT was significant for women without GDM, $\beta=0.422$, $p<0.001$, but nonsignificant for those with GDM, $\beta=0.124$, p=0.332. In other words, this suggests that ATT tends to be related to intention, but only for women without GDM. This result needs to be considered with caution, however, given that it did not reach the p=0.05 statistical significance threshold.

Identification of beliefs predicting intention toward MVPA in pregnant women (objective 3) and difference in beliefs differ according to women's GDM (objective 4)

The model for BB on ATT had an adequate fit after adding 2 covariances (att3 with both att1 and att2): $\chi^2_{(175)} = 344.233$, $p<0.001$, RMSEA = 0.077, CFI = 0.940, TLI = 0.933. bb4 (pregnancy-related discomforts and pains) and bb6 (mental health) were statistically related to ATT ($\beta=0.091$, p=0.006 and $\beta=0.749$, $p<0.0001$, respectively). bb2 (fatigue) was marginally related to ATT ($\beta=0.055$, p=0.087). The multigroup SEM analysis revealed a statistical difference between women without GDM and those with GDM on bb4 (d=−0.243, p=0.002) and bb2 (d=0.193, p=0.009). bb4 (pregnancy-related discomforts and pains) was positively related to ATT in women with GDM ($\beta=0.289$, $p<0.001$) but not in those without GDM ($\beta=-0.047$, p=0.197). Conversely, bb2 (fatigue) was positively related to ATT in women without GDM ($\beta=0.094$, p=0.010) but not in those with GDM ($\beta=-0.099$, p=0.125).

The model for NB on SN had an adequate fit: $\chi^2_{(50)} = 94.182$, $p<0.001$, RMSEA = 0.072, CFI = 0.961, TLI = 0.953. All NB were

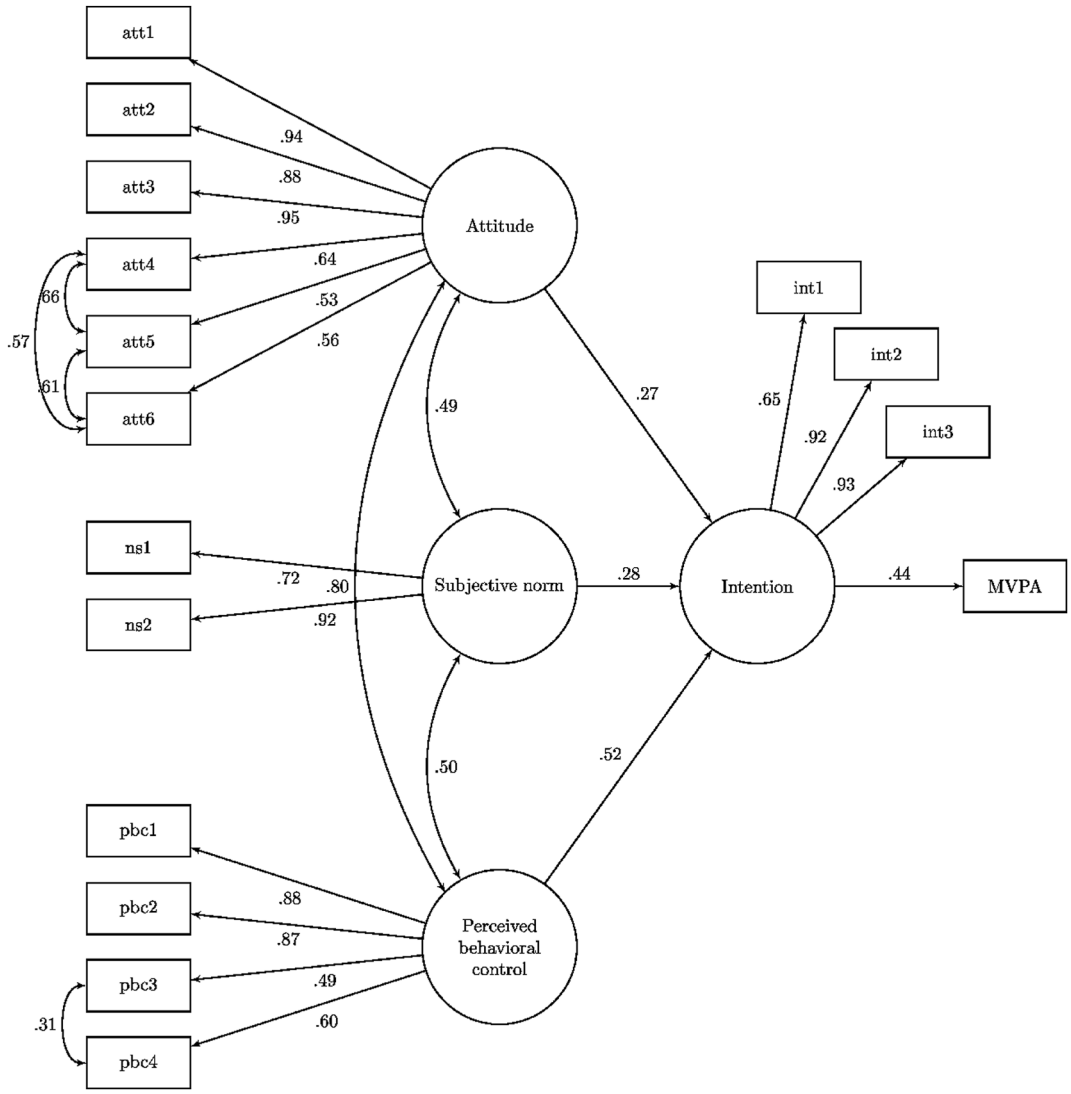


Figure 2. Initial structural mode. att1 to att6, sn1 and sn2, pbc1 to pbc4, and int1 to int3 are presented in Supplementary Table 1. Numbers presented are regression coefficients. *MVPA*, moderate-to-vigorous physical activity.

statistically related to SN. The multigroup SEM analysis revealed a statistical difference (d=−0.236, p=0.011) between women without GDM and those with GDM on nb1 (health professionals), showing a significant positive relationship in women with GDM (β=0.149, p=0.023), but not in those without GDM (β=−0.088, p=0.179).

Finally, the model CB on PBC had an adequate fit: $\chi^2_{(141)} = 267.962$, p<0.001, RMSEA = 0.073, CFI = 0.930, TLI = 0.924. cb1 (lack of time), cb2 (fatigue), cb3 (lack of social support), and cb5 (pregnancy-related symptoms) were positively and statistically related to PBC (p<0.001 for the first 3 and p=0.0024 for the last). The multigroup SEM analysis revealed a statistical difference between women without GDM and those with GDM on cb1 (lack of time) (d=−0.269, p=0.002) and cb2 (fatigue) (d=0.273, p=0.006). The first was positively related to PBC in women with GDM (β=0.282, p<0.001) but not those without GDM (β=0.014, p=0.830), whereas the second was positively related to PBC in both women with and without GDM, but the relationship was stronger in the former (β=0.458, p<0.001) compared with the latter (β=0.185, p=0.008).

Discussion

Principal findings

The first and second objectives of this study were to validate the TPB model for predicting MVPA in pregnant women and to determine whether the model would vary according to GDM status. Using a larger sample size than that used by Simard et al [30], our results confirm that the TPB model is valid for predicting MVPA in pregnant women, and that there is a significant moderating effect of PBC on the relation between intention and MVPA. We found that, when considering a pool of woman with different GDM status (with or without GDM), the relationship between intention and MVPA was stronger when PBC was greater than the mean. In other words, when women felt more confident than average in their capacity to be regularly active, or perceived regular MVPA as easier to perform, the translation of intention into behaviour was stronger. This finding is consistent with previous results observed in pregnant women without GDM [30] and aligns with the TBP postulate that PBC plays a key role in bridging the

Table 1
Baseline characteristics of participants

	Total participants (n=340)	Women without GDM (n=191)	Women with GDM (n=149)
Variables			
Age, years	31.4 ± 4.0	31.3 ± 3.6	31.5 ± 4.5
Ethnicity			
Caucasian	313 (92.0%)	185 (96.9%)	128 (86.5%)
Other	26 (8.0%)	6 (3.1%)	20 (13.5%)*
Education level			
University degree	239 (70.3%)	155 (81.2%)	84 (56.4%)
Other	101 (29.7%)	36 (18.8%)	65 (43.6%)*
Gravidity			
Primigravida	192 (56.6%)	121 (63.4%)	71 (48.0%)
Multigravida	147 (43.3%)	70 (36.6%)	77 (52.0%)*
BMI prepregnancy, kg/m^2	27.2±7.14	24.2±4.6	31.1±7.9*
Prepregnancy BMI categories, kg/m^2			
<25.0	169 (49.9%)	127 (66.5%)	42 (28.4%)
25–29.9	78 (23.0%)	45 (23.6%)	33 (22.3%)
≥30.0	92 (27.1%)	19 (9.9%)	73 (49.3%)*
Gestational age, weeks	21.7 ± 8.2	20.5 ± 7.6	27.1 ± 7.1*
Stage of pregnancy			
First trimester (≤14 weeks)	66 (19.5%)	54 (28.3%)	12 (8.1%)
Second trimester (15–28 weeks)	162 (47.9%)	108 (56.5%)	54 (36.7%)
Third trimester (≥29 weeks)	110 (32.5%)	29 (15.2%)	81 (55.1%)*
Gestational age at GDM diagnosis, weeks	–	–	21.2±8.3
Personal history of GDM			
First diagnosis of GDM	–	–	109 (73.2%)
Insulin therapy			
Yes	–	–	68 (45.9%)
PA levels†			
MVPA (min/week)	128.8±106.0	146.9±101.5	106.4±107.6*
≥150 min/week of MVPA	125 (38.3%)	80 (44.4%)	45 (30.8%)
<150 min/week of MVPA	201 (61.7%)	100 (55.6%)	101 (69.2%)*

BMI, body mass index; *GDM*, gestational diabetes mellitus; *MVPA*, moderate-to-vigorous physical activity; *PA*, physical activity.
Note: Data expressed as mean (standard deviation) or as number (%).
* Significant difference ($p<0.05$) between women without GDM and women with GDM.
† Data available for 180 women without GDM and 146 women with GDM.

intention–behaviour gap, particularly when behaviour is perceived as challenging, such as during pregnancy.

Determinants of MVPA among women with and without GDM

When examining whether determinants of MVPA vary between women with and without GDM, we found only one marginal difference ($p=0.06$) regarding the relationship between attitude toward MVPA and intention, suggesting that this association may be weaker or nonsignificant in women with GDM. However, given that this difference did not reach conventional levels of statistical significance, and that this is the first study to test this model specifically in pregnant women with GDM, caution is warranted in interpreting this finding. At this stage, we refrain from drawing firm conclusions about a differential role of attitude in women with GDM. Further quantitative studies with larger samples, as well as qualitative approaches exploring how women with GDM conceptualize the benefits and drawbacks of MVPA, would be valuable to clarify this relationship.

No differences according to GDM status were observed regarding the positive relationship between PBC or SN and intention toward the MVPA, suggesting that these constructs are robust determinants of intention regardless of GDM status. These results are consistent with previous studies [30,57] and extend them by suggesting that, at the level of proximal TPB constructs, the motivational architecture underlying MVPA intention may be largely similar in women with and without GDM. Nevertheless, as discussed in what follows, important differences emerged at the belief level, highlighting the relevance of examining distal cognitive determinants to inform tailored interventions.

PA beliefs in women with and without GDM

The third and fourth objectives were to identify which beliefs indirectly (through attitude, SN, and PBC) predict intention toward MVPA in pregnant women and whether these beliefs differed according to GDM status. In accordance with previous studies [27,30,34,36,38,39], results indicate that women, independently of GDM status, reported stronger intention toward MVPA when they believed that regular MVPA would not increase fatigue or pregnancy-related discomfort and would improve mental well-being. These findings reinforce the importance of behavioural beliefs related to both physical comfort and psychological benefits in shaping attitudes toward prenatal MVPA.

However, pregnancy-related discomfort and fatigue beliefs were differentially associated with intention in women with and without GDM. Specifically, in women with GDM, beliefs related to pregnancy-related discomfort were associated with less favourable attitudes toward MVPA, whereas this association was not observed in women without GDM. These results suggest differences in perceptions or anticipatory beliefs regarding MVPA-related discomfort in women with GDM. From a TPB perspective, this indicates that women with GDM may assign greater weight to beliefs related to bodily discomfort when forming attitudes toward MVPA.

One plausible interpretation is that women with GDM, who often experience a more medicalized pregnancy trajectory, may be more attentive to bodily sensations and perceived risks, which could amplify concerns about discomfort associated with MVPA. Importantly, this heightened sensitivity may extend beyond physical sensations to encompass psychological strain, increased mental load, and the perception of an “abnormal” pregnancy [58,59]. In addition, the self-regulatory burden associated with

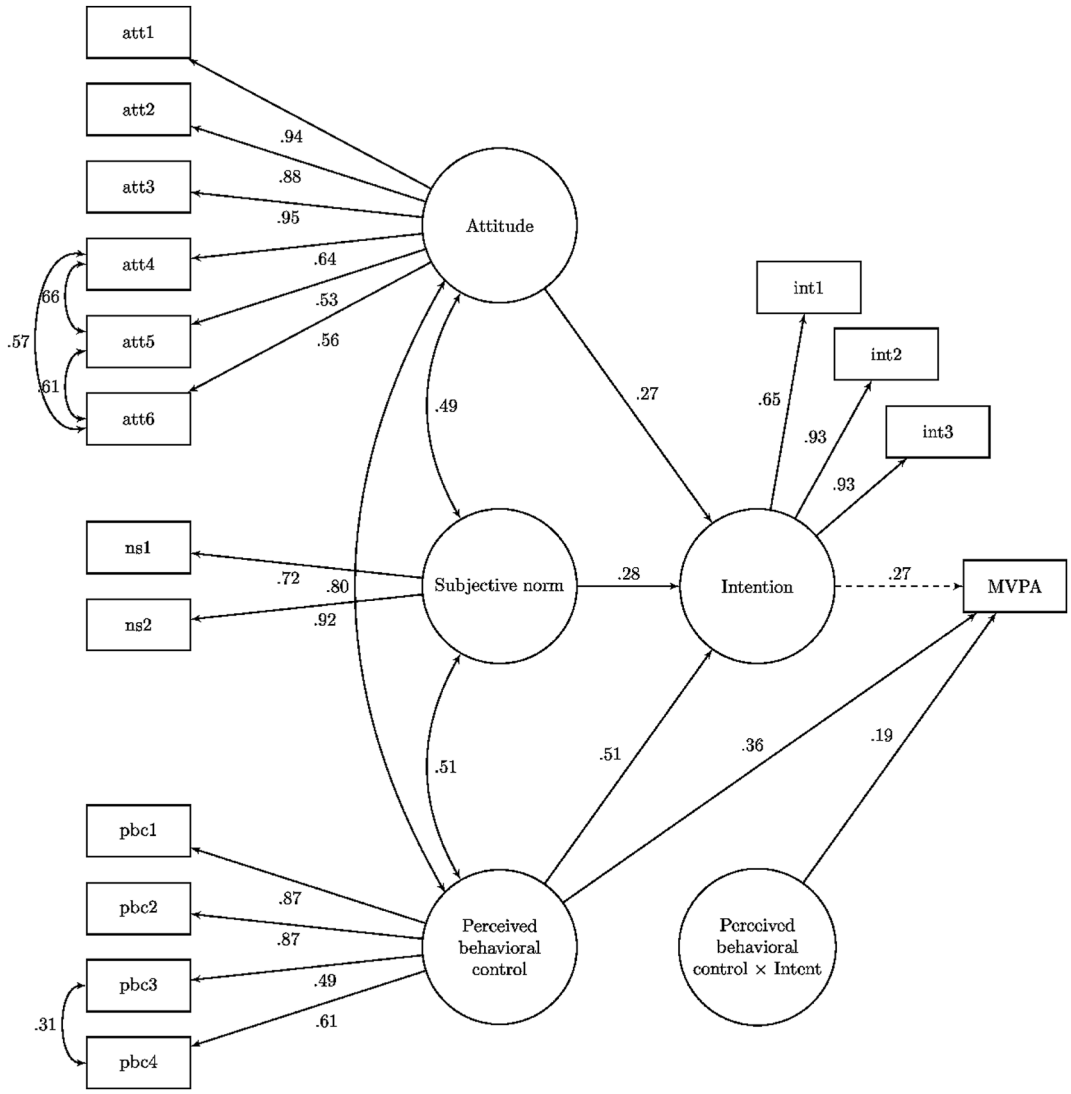


Figure 3. Standardized estimates of the final model with PBC × intention added. att1 to att6, sn1 and sn2, pbc1 to pbc4, and int1 to int3 are presented in Supplementary Table 1. Numbers presented are regression coefficients. *MVPA*, moderate-to-vigorous physical activity.

GDM management (e.g. dietary restrictions, glucose monitoring, insulin injections) may heighten sensitivity to additional perceived demands, including recommendations related to PA. These interpretations remain speculative because we did not assess indicators of psychological distress, treatment burden, or insulin use in this study. Further investigation is warranted using designs that integrate objective and subjective measures of physical symptoms and qualitative data to better capture lived experiences. Nevertheless, it is noteworthy that a substantial body of evidence indicates that MVPA during pregnancy can reduce pregnancy-related discomforts [60–63], suggesting that some concerns may reflect a mismatch between beliefs and empirical evidence in some women with GDM. This further underscores the importance of delivering PA recommendations in a supportive, nonburdensome manner that acknowledges women's broader psychosocial context.

Consistent with previous studies [28,30,37,64], the women in our study reported stronger intention toward MVPA when they believed that significant-others, including parents, partners, friends, and health-care providers, would approve of their behaviour. Notably, approval from health-care providers emerged as a significant predictor of intention in women with GDM but not in those without GDM. This finding is consistent with the clinical context of GDM, where women typically receive more frequent follow-up and interact with a specialized health-care team. Given that regular PA constitutes a first-line therapy for GDM management [13], and that women with GDM are highly motivated to adopt lifestyle changes [42,65], health-care providers may represent particularly salient referents in shaping normative beliefs in this group.

Finally, although lack of energy, time, social support, and physical limitations are commonly reported barriers to prenatal PA [27,33–39], the women in our sample indicated that these factors did not strongly limit their PBC. This suggests that women may have developed strategies, resources, or a strong sense of efficacy to overcome these barriers, possibly reflecting the relatively high education level of the sample. Interestingly, lack of time was positively associated with PBC in women with GDM but not in those without GDM. This finding suggests that women with GDM may prioritize MVPA despite time constraints, potentially due to heightened awareness of its role in managing their condition.

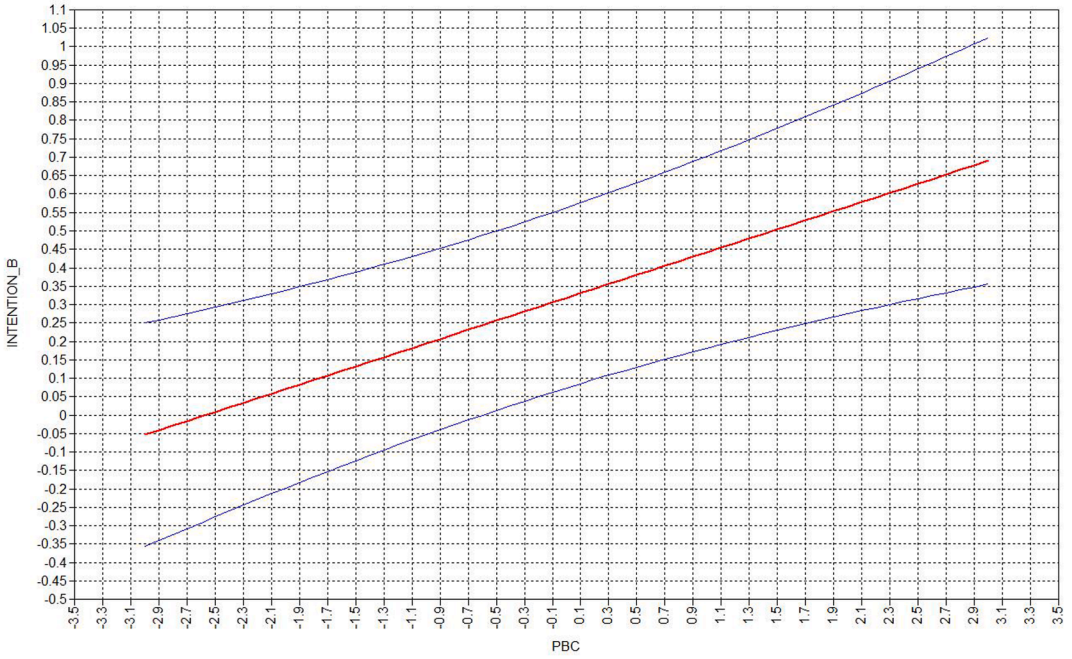


Figure 4. Johnson–Neyman plot of the effect of the moderator perceived behavioural control (PBC) on the relation between moderate-to-vigorous physical activity on intention.

Again, this interpretation should be considered cautiously, as time availability and competing demands were not objectively assessed.

Implications for clinical practice or health education

The present findings have several practical implications for clinical practice and prenatal health education. First, given the central role of PBC in translating intention into MVPA, interventions should prioritize strategies that enhance women's confidence in their ability to be active during pregnancy. This may include goal-setting, problem-solving around common barriers, and providing concrete examples of feasible MVPA adapted to pregnancy-related symptoms. Second, the belief-level differences observed between women with and without GDM underscore the need for tailored messaging. For women with GDM, interventions may benefit from explicitly addressing concerns related to pregnancy-related discomfort and pain by providing evidence-based reassurance and practical guidance on how MVPA can be adapted to minimize discomfort. Clinicians could, for instance, emphasize low-impact activities, gradual progression, and symptom-monitoring strategies, while reinforcing that MVPA is generally safe and beneficial when appropriately prescribed. Importantly, although PA is a cornerstone and first-line component of GDM management, counselling is often delivered in a relatively generic manner during an already complex clinical follow-up. Moreover, multidisciplinary teams responsible for GDM care do not systematically include a kinesiologist—the health professional whose expertise is specifically centred on PA assessment, prescription, and behaviour change support. Integrating a kinesiologist within GDM care teams could facilitate the development of tailored, evidence-based PA promotion strategies that account for pregnancy-related symptoms, perceived barriers, glycemic targets, and individual belief profiles. Such integration may strengthen PBC and improve the translation of intention into sustained MVPA participation. Third, the prominent role of health-care provider approval in women with GDM highlights the importance of consistent, explicit, and supportive PA counselling from the health-care team. Training health-care providers to deliver clear, unified messages about MVPA and personalizing recommendations according to women's beliefs and perceived barriers may be particularly effective in this population. In contrast, for women without GDM, involving partners or family members in PA promotion strategies may help strengthen subjective norms. Overall, these results suggest that interventions grounded in the TPB and informed by belief-level differences can be optimized by tailoring their content to women's GDM status and lived experiences during pregnancy.

Strengths and limitations

Our study has several strengths. To our knowledge, this study is the first to explore whether determinants of prenatal PA vary between women with and without GDM using a recognized theoretical framework and therefore addressing a gap in the existing literature. Comparing beliefs between women with and without GDM has allowed us to identify health status–specific beliefs, which can help refine and tailor interventions promoting PA. Using structural equation modelling analyses allowed us to test a series of causal connections and to examine how several dependent and independent variables interact simultaneously, as suggested by Barbeau et al [53]. In addition, given that the predictive validity of the TPB depends on the temporal stability of its constructs, follow-up duration was adapted according to women's clinical status. In women with GDM, a shorter follow-up interval (2 weeks) was used to account for the rapid clinical, behavioural, and contextual changes occurring after GDM diagnosis, which are likely to influence PBC and intention toward PA. In contrast, women without GDM were followed over 4 weeks, reflecting a more stable pregnancy context and allowing sufficient time to capture habitual PA behaviour.

Some study limitations also need to be mentioned. Prenatal PA was assessed using the short version of the IPAQ, a reliable and valid tool [44] commonly used to assess PA practice in pregnant women [45]. As PA was self-reported, some degree of overestimation cannot be excluded [66]. However, this would have been the case in both women with and without GDM. Moreover, it

is unlikely that women who may have overestimated their PA levels would have answered the TPB-related questions differently from those who would not. To enhance analytical robustness, conservative outlier handling was applied. Also, for the purpose of our study, questions were asked about PA practice over the past 2 to 4 weeks (to assess the outcome variable), and not the past week, as in the original IPAQ. Although this specific recall period has not been formally revalidated as a distinct instrument, the questions themselves remained unchanged, preserving the content validity and construct coverage of the original questionnaire. However, we acknowledge that, due to the recall time frame adaptation of the IPAQ questions, greater recall bias cannot be excluded, more specifically in women without GDM in whom we assessed the level of PA over the previous 4 weeks. Furthermore, the use of different recall durations may have introduced some degree of measurement heterogeneity. Future studies would benefit from using an objective tool for measuring PA, such as the accelerometer, in addition to the IPAQ, to obtain a more accurate representation of women's PA levels [67]. Regarding the sample, its relative homogeneity and high educational and PA levels may limit its representativeness and the extent to which the findings can be generalized to women from more diverse backgrounds, such as those with lower socioeconomic and PA levels. The sample of women with GDM may also not be fully representative of the broader population of women with GDM in Québec (Canada), based on early gestational age of GDM diagnosis. Therefore, the possibility of selection bias cannot be totally ruled out.

In conclusion, this study supports the usefulness of the TPB for understanding MVPA during pregnancy in women with and without GDM. Intention emerged as a key predictor of MVPA, particularly when PBC was high, highlighting the importance of women's confidence in their ability to be active during pregnancy. Although the overall TPB structure was largely similar across groups, meaningful differences were observed at the belief level. Pregnancy-related discomfort beliefs and health-care provider approval played more prominent roles in shaping intentions among women with GDM. These findings underscore the relevance of targeting specific behavioural, normative, and control beliefs when designing interventions and suggest that tailoring PA promotion strategies according to GDM status may enhance their effectiveness.

Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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Data generated or analyzed during this study cannot be made publicly available due to ethical constraints. Participants did not provide consent to make their data available beyond the scope of this study. Consequently, data sharing has been restricted to protect participant confidentiality and privacy in compliance with the ethical standards of the local ethics committee.

Author Disclosures

Conflicts of interest: None.

Author Contributions

S.-M.R. conceived the study and coordinated and supervised data collection; S.-M.R., S.G., J.L., and P.-O.C. contributed to the design of the study; V.B., J.-P.B., S.J.W., and E.R. helped with recruitment of participants; L.S. and S.P. collected the data; P.-O.C. performed the statistical analyses; P.-O.C., S.G., J.L., and S.-M.R. assisted with interpretation of the results; S.P. drafted the initial manuscript with major contributions from S.-M.R., S.G., and J.L. All authors contributed to revision of the final version of the manuscript submitted for publication. S.-M.R. is the guarantor.

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Supplementary Table 1
Description of the psychosocial variables

Variables [*]	7-point scales (1–7)
Intention	
int1—I intend to practice regularly one or more physical activities in my free time over the next month.	unlikely/likely
int2—My plans are to practice regularly one or more physical activities in my free time over the next month.	disagree/agree
int3—I estimate that my chances of practicing regularly one or more physical activities in my free time over the next month are …	weak/good
Attitude	
For me, practicing regularly one or more physical activities in my free time over the next month would be …	att1—unenjoyable/enjoyable att2—dull/interesting att3—unpleasant/pleasant att4—bad/good att5—useless/useful att6—disadvantageous/advantageous
Subjective norm	
sn1—Over the next month, if you practice regularly one or more physical activities, most of the people who are important to you …	disapprove/approve
sn2—Most people who are important to me think I should practice regularly one or more physical activities in my free time over the next month.	disagree/agree
Perceived behavioural control	
pbc1—I feel capable of practicing regularly one or more physical activities in my free time over the next month.	disagree/agree
pbc2—For me, practicing regularly one or more physical activities in my free time over the next month would be …	difficult/easy
pbc3—It is completely up to me whether I practice regularly one or more physical activities in my free time over the next month.	disagree/agree
pbc4—How much control do you feel you have over the fact of practicing regularly one or more physical activities in your free time over the next month?	no control at all/complete control
Behavioural beliefs	
If I practiced regularly one or more physical activities in my free time over the next month, I would …	unlikely/likely
bb1—be in better physical condition	
bb2—be more tired [†]	
bb3—manage my weight gain better	
bb4—have pregnancy-related discomforts and pains[b]	
bb5—have better preparation for childbirth	
bb6—feel better mentally	
bb7—foster better health for the baby	
Normative beliefs	
nb1—My partner would disapprove / approve of me practicing regularly one or more physical activities over the next month.	disapprove / approve
nb2—Health professionals would disapprove / approve of me practicing regularly one or more physical activities over the next month.	
nb3—My friends would disapprove / approve of me practicing regularly one or more physical activities over the next month.	
nb4—My parents would disapprove / approve of me practicing regularly one or more physical activities over the next month.	
Control beliefs	
cb1—If I was lacking time over the next month, I would still practice regularly one or more physical activities.	unlikely/likely
cb2—If I was tired over the next month, I would still practice regularly one or more physical activities.	
cb3—If I was missing social support over the next month, I would still practice regularly one or more physical activities.	
cb4—If I had discomfort and pain during over the next month, I would still practice regularly one or more physical activities.	
cb5—If I had some limitations in my activities over the next month (e.g. nausea, vomiting, etc), I would still practice regularly one or more physical activities.	
cb6—If I had any concerns about the safety of the baby over the next month, I would still practice regularly one or more physical activities.	
cb7—If I did not have easy access to sports facilities over the next month (e.g. fitness centre, swimming pool, etc), I would still practice regularly one or more physical activities.	
cb8—If I did not have access to a supportive environment over the next month (e.g. park, bike path, walking trails, etc), I would still practice regularly one or more physical activities.	

[*] Free translation from French. For women with gestational diabetes mellitus, the questions were asked about physical activity over the next 2 weeks.
[†] These 2 behavioural beliefs were negatively written so they were recoded (unlikely = 7; likely = 1).